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GRASS MORPHOLOGY AND SYSTEMATICS

I. THE INTERNODE

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ABSTRACT. Examination of internodes of 133 species of grasses from 80 genera of 21 tribes indicates that the often-repeated statement that, "the internodes of grasses are usually hollow," is either misleading or incorrect. Data from the above study and other reports demonstrate that 54 per cent of 190 species have solid internodes. Among the Festucoideae about 7 per cent of species have solid internodes. Among the tribes of the Panicoideae solid internodes range from 46 per cent in the Paniceae to 100 per cent in the more specialized arid land tribes. The character of internodes is of taxonomic value. It may be of survival value in the contrasting environments occupied by the various tribes.

Nearly all authors of general treatments of grasses have stated that grass internodes are usually hollow (Hackel, 1890; Hitchcock, 1914; Bews, 1929; Arber, 1934; Armstrong, 1937; Chase, 1959; etc.). A qualifying statement is sometimes appended to the effect that in some groups, such as the Andropogoneae, Paniceae, etc., internodes are or may be solid. Canfield (1934), on the other hand, reported that 74 per cent of the grasses examined from the Jornada Experimental Range Station near Las Cruces, New Mexico, had solid internodes. He related the solid stem structure to the environment and concluded that hollow-stemmed grasses are not well adapted to arid regions.

The general statement that grass internodes are usually hollow originated in the cool temperate regions such as Germany, England, and northeastern United States, where most of the native and introduced grasses probably do have hollow internodes. On the other hand, the report of Canfield and casual observations by the present authors have indicated that many grasses of the southwestern United States have solid internodes. The present investigation consisted of an examination of available species and assemblage of pertinent data as a sample for judging whether most grasses do have hollow internodes or not; and also to determine if there is any correlation between solid or hollow internodes and taxonomic groupings.

MATERIALS AND METHODS

Pieces of mature grass culms were collected fresh, fixed in Navashin's fluid, and stored in 70 per cent alcohol until examined. Other

culms were collected from growing plants and examined immediately.

The plants that furnished the material for the study were native to the Austin, Texas region, or were adventive there, or were species from distant American or foreign regions either collected there as specimens or grown from seed in a grass nursery at Austin. We thank the numerous individuals who contributed material of the many foreign species.

A total of 133 species in 80 genera of 21 tribes was examined. In the preparation of Table 2, data from other reports, especially that of Canfield (1934), were used. That table summarizes information about 190 species in 85 genera. The species and genera are arranged in Table 1 by tribes and these are grouped in larger categories.

TABLE 1.

Species examined with character of internode (H—hollow, SH—small hollow, S—solid) and pulvinus (S—sheath pulvinus, C—culm pulvinus, IS—indefinite sheath pulvinus, IC—indefinite culm pulvinus).

Species	Internode	Pulvinus
Subfamily FESTUCOIDEAE		
Festuceae		
Briza media	H	S
Bromus catharticus	SH	S + IC
B. japonicus	H	S
B. purgans	H	S
B. rigidus	H	S
Dactylis glomerata	H	S
Festuca rubra	SH	S + IC
Lolium multiflorum	H	S
Melica mutica	H	S
Poa arachnifera	S	S
P. annua	SH	S
Scleropoa rigida	SH	S
Vulpia octoflora	H	S
Aveneae		
Avena sativa	H	S
Trisetum interruptum	H	S
Agrostideae		
Calamagrostis canadensis	H	S
Limnodea arkansana	H	S + C
Phleum pratensis	S	S
Polypogon monspeliensis	SH	S

Hordeae		
Agropyron smithii	SH	S
Elymus canadensis	H	S
E. virginicus	H	S
Hordeum pusillum	H	S
H. vulgare	H	S
Phalarideae		
Anthoxanthum aristatum	SH	S + IC
Phalaris arundinacea	H	S
P. caroliniana	H	S
P. tuberosa	H	S + IC
Subfamily PANICOIDEAE		
Supertribe EUPANICOIDEAE		
Paniceae		
Anthephora cristata	SH	S + C
A. pubescens	SH	S + C
Cenchrus myosuroides	SH	S + C
C. pauciflorus	S	C
Digitaria milanjiana	SH	S + C
D. sanguinalis	SH	S + C
D. valida	SH	....
Eriochloa sericea	SH	S + IC
Leptoloma cognatum	H	S + IC
Panicum antidotale	S	S + C
P. coloratum	H	S
P. fasciculatum	S	S + C
P. makarikariense	H	C
P. maximum	H	C
P. obtusum	S	S
P. pedicellatum	SH	IC
P. texanum	H	S + C
P. virgatum	H	IS
Paspalum dilatatum	H	C
P. distichum	S	C
P. pubiflorum	S	S
P. urvillei	H	S + C
Pennisetum ciliare	S	C
P. villosum	S	S
Setaria geniculata	SH	S + C
S. holstii	SH	S + C
S. macrostachya	S	S + C
Stenotaphrum secundatum	S	S + C
Trichachne insularis	H	S + IC
Urochloa mosambicensis	S	S + C
Andropogoneae		
Amphilophis barbinodis	S	C
A. saccharoides	S	IS + C

Species	Internode	Pulvinus
Arthrolophis glomeratus	SH	S + C
Bothriochloa ischaemum	S	S + IC
Chrysopogon montanus	S	IS + C
Cymbopogon martinii	S	IS + C
C. schoenanthus	S	S + IC
Dichanthium annulatum	S	S + C
Heteropogon contortus	S	C
Hyperrhenia hirta	S	S + C
Ischaemum glaucostachyum	S	S + C
Schizachyrium scoparium	S	IS + C
Sorghum halepense	S	S + IC
Sorghastrum nutans	SH	S + C
Themeda triandra	S	S + C
Veteveria zizanioides	SH	S + C
Mayreae		
Tripsacum dactyloides	S	C
Zea mays	S	S + C
Supertribe CHLORIDOIDEAE		
Chlorideae		
Bouteloua breviseta	S	S + IC
B. curtipendula	S	S
B. gracilis	S	S + C
B. hirsuta	S	S
B. pectinata	S	S
B. radicosa	S	S + IC
B. rigidiseta	S	S
Chloris cuculata	S	S + C
C. distichophylla	S	S + IC
C. gayana	S	S + C
C. verticillata	S	S + C
Cynodon dactylon	SH	IS + C
Enteropogon sp.	S	S
Leptochloa dubia	S	S + IC
L. filiformis	H	S
Spartina patens	H	S + IC
Trichloris pluriflora	S	S + C
Schedonnardus paniculatus	S	S
Eragrosteae		
Distichlis texana	SH	S
Eragrostis curvula	SH	S + C
E. intermedia	H	IC
E. pectinacea	SH	S + C
E. spicata	SH	S
E. superba	S	S + C
Scleropogon brevifolius	S	S

Tridens muticus	S	S + C
T. pilosus	S	S + IC
Pappophoreae		
Enneapogon sp.	S	S + C
Pappophorum bicolor	S	S + C
Sporoboleae		
Muhlenbergia reverchoni	SH	S
M. rigens	SH	....
M. utilis	S	S
Sporobolus airoides	S	S
S. asper	S	S
S. cryptandrus	S	S
S. neglectus	S	S
S. vaginiflorus	S	S
S. wrightii	S	IS
Zoysieae		
Hilaria belangeri	S	S + IC
Latipes senegalensis	SH	S + C
Pleuraphis mutica	S	....
Tragus berteronianus	S	S + IC
Aristideae		
Aristida oligantha	S	IS + C
A. purpurea	S	S + C

PHRAGMITIFORMES

Arundineae		
Arundo donax	H	S + C
Phragmites communis	H	C
Bambuseae		
Phyllostachys sp.	H	C
Bambusa sp.	H	C
Oryzeae		
Leersia oryzoides	H	S
Zizania aquatica	S	S
Stipeae		
Stipa leucotricha	S	S + IC
S. tenuissima	SH	S
Oryzopsis hymenoides	S	S
O. asperifolia	H	S + IC
Unioleae		
Uniola latifolia	SH	S + C

Species	Internode	Pulvinus
Danthonieae		
Danthonia spicata	SH	S + C
Ehrharteae		
Ehrharta longifolia	S	S + IC

TABLE 2

Grasses arranged by major groups and tribes to show numbers of species having hollow or solid internodes. Data from this study and other reports.

Tribe	No. Species	INTERNODES Hollow	Small hollow	Solid
		FESTUCOIDEAE		
Festuceae	13	8	4	1
Hordeae	12	9	1	2
Phalarideae	4	3	1	0
Agrostideae	4	2	1	1
Aveneae	3	3	0	0
Totals	36	25	7	4
		PANICOIDEAE EUPANICOIDEAE		
Paniceae	36	13	10	13
Andropogoneae	18	0	3	15
Maydeae	2	0	0	2
Totals	56	13	13	30
		CHLORIDOIDEAE		
Chlorideae	25	3	1	21
Eragrosteae	16	3	4	9
Pappophoreae	3	1	0	2
Zoysieae	5	0	1	4
Sporoboleae	20	0	2	18
Aristideae	9	0	0	9
Totals	78	7	8	63
		PHRAGMITIFORMES		
Bambuseae	5	5	0	0
Arundineae	2	2	0	0
Oryzeae	3	2	0	1
Unioleae	1	0	1	0
Stipeae	7	3	1	3
Danthonieae	1	0	1	0
Ehrharteae	1	0	0	1
Totals	20	12	3	5
GRAND TOTALS	190	57	31	102
		88 = 46%		102 = 54%

RESULTS AND DISCUSSION

It is evident that the number of species of Festucoideae studied was small. Species of this subfamily are relatively few in southwestern United States where they grow as winter grasses. Canfield (1934) examined very few festucoid grasses for the same reason. Table 2, therefore, which is based chiefly on this study and that of Canfield, may be slightly biased in favor of the Panicoideae. Nevertheless, there are far more species and genera of Panicoideae than of Festucoideae and so Table 2 may actually be a representative sample of the earth's grasses.

The group Phragmitiformes is an artificial assemblage of genera consisting of tribes of uncertain relationships, and it is used here merely for convenience. The groups Festucoideae, Eupanicoideae, and Chloridoideae have been shown to be natural by numerous studies (Stebbins, 1957; Brown, 1958; etc.).

This study revealed that a simple distinction of hollow or solid is inedaquate to correctly describe grass internodes. A large number of panicoid grasses have thick walls and small hollows in contrast to most festucoid grasses that have thinner walls and larger hollows. In Table 2, therefore, species are tabulated as hollow, small-hollow, or solid. Furthermore, relative hollowness may vary to some extent among the species of a genus as in *Triticum* (Percival, 1936). Genetic strains of commercial wheat also vary in hollowness (cf. Sears, 1948). Relatively short basal internodes may be solid although the fully elongated upper internodes may be hollow. In some species, elongated lower or upper internodes or peduncles may be solid, whereas the other internodes above or below may be hollow (Percival, 1936, for wheat; McClure, 1957, for a bamboo; and some species examined in this study). Nevertheless, it is possible to propose tentative generalizations about the interior of grass internodes based on available information.

In such tribes as the Unioleae, Danthonieae, Ehrharteae, and some others, the sample is too small to more than indicate the possible general condition of internodes for the tribes.

On the basis of the sample represented in Table 2, 54 per cent of grass species are known to have solid internodes. The available data, therefore, suggest that more grass species have solid than have hollow internodes.

Almost all species of the Festucoideae have hollow internodes; only about 7 per cent of the 36 species cited in Table 2 have solid internodes. In contrast, 68.7 per cent of the Panicoideae have solid internodes.

Among the tribes of the Panicoideae, there is considerably more range in percentages of species with solid internodes than there is among tribes of Festucoideae with respect to hollow internodes. In the latter group, species with solid internodes are very uncommon. The variation among the tribes of the Panicoideae is evident if they are arranged with respect to percentages of species with solid internodes, as follows:

Maydeae	100%	Sporoboleae	80%	Pappophoreae	67%
Aristideae	100%	Andropogoneae	78%	Eragrosteae	57%
Zoysieae	80%	Chlorideae	78%	Paniceae	49%

Of these tribes there is a correlation between highly specialized spikelets and/or inflorescences and solid internodes. The Maydeae, Andropogoneae, Aristideae, Zoysieae, and Sporoboleae have the greatest spikelet modification and reduction among tribes of the Panicoideae. The Chlorideae, Pappophoreae, Eragrosteae and especially the Paniceae have the least specialized spikelets and inflorescences.

Canfield's conclusion that hot season arid-land grasses are apt to have solid internodes was based on a sample that consisted of 90 per cent Panicoideae. Of the 59 species of the Panicoideae reported by Canfield, 12 are classified in the subgroup Eupanicoideae, whereas 47 are species of the subgroup Chloridoideae. The Chloridoideae, species characterized by a high percentage of solid stems, are the characteristic species of the more arid tropical and subtropical regions. In contrast, a much higher percentage of species having hollow internodes would be expected in tropical and subtropical regions of high rainfall. Such regions contain low numbers of species of Chloridoideae but high percentages of the tribe Paniceae, a tribe containing about 50% of species with hollow internodes. Regions with intermediate rainfall should have a lower percentage of species with solid internodes than the 74% found by Canfield but more than one would expect from hot regions of high rainfall. For example, at Austin, Texas, such an intermediate region, about 58 per cent of native species studied have solid internodes. Extrapolation would indicate an even lower percentage of solid internode species in very humid tropical or subtropical regions. Even within the larger tribes of the Panicoideae it may be that species of the arid regions in general tend to have solid internodes, whereas species of the same tribes or even genera native to more humid regions may have, more often, hollow internodes.

Within the Panicoideae it can be concluded that the tribes with the most highly specialized floral structures, which are also the tribes of the more arid regions, have a higher percentage of species with solid

internodes. At this time it is not possible to state whether the more specialized tribes occupy arid regions because they have solid internodes, or whether they have solid internodes because they grow in arid regions, or whether the correlation between solid internodes and arid regions is merely fortuitous. Nevertheless, solid or nearly solid internodes may be of advantage to grasses of hot, dry, windy regions.

Conversely, hollow internodes may be of selective advantage to the grasses of alpine, arctic, and cool temperate meadow or forest-margin habitats, as well as to winter grasses of warmer temperate regions; that is, the Festucoideae.

Taxonomically, the hollowness or solidness of internodes is to some extent correlated with a wide variety of characters of importance in grass systematics that have been investigated and discussed during the last thirty years. Chromosome size, basic chromosome number, characters of interphase nuclei of somatic cells, types of starch grains, morphology of the first seedling leaf, and, to some extent, leaf anatomy were studied or discussed by Avdulow (1931). Prat (1936) correlated silica cell shape and bicellular epidermal hairs with taxonomic groups. Van Tieghem (1897) and Reeder (1957) have demonstrated that two or three characters of mature embryos of grass seeds are correlated with certain systematic concepts. Schwendener (1890), Lohauss (1905), Brown (1958), and others have concluded that the arrangements of tissues and physiological activities of these tissues in the leaf blade are useful taxonomic characters. Brown and Emery (1957), Brown, *et al.* (1957), and Al Aish and Brown (1958) have correlated persistence of nucleoli at metaphase of mitosis, number of tunica layers on the stem apex, and responses of germinating grass seeds to treatment by Isopropyl-N-phenyl carbamate with taxonomic groups. Row and Reeder (1957) have demonstrated differences of root epidermal cells and root hairs between certain major groups of the grass family.

From all of these diverse studies a new concept of the interrelationships among tribes and groups of tribes has been developed (Stebbins, 1956; Brown, 1958). The condition of the internode is another character of this sort. The Festucoideae are a group characterized by thin-walled, hollow internodes. Among the Panicoideae there is a tendency for internodes to be solid, although there are many exceptions, but hollowness is much less prevalent than among the festucoid grasses. Among the Phragmitiformes, an admittedly artificial group, some tribes appear to be characterized by solid internodes whereas others have internodes as hollow as species of the Festucoideae. It is evident that the Festucoideae are very distinct from the Panicoideae, and that

although the Eupanicoideae differ in some respect from the Chloridoideae these two supertribes have a number of characters in common.

It is impossible to state whether the earliest primitive grasses had hollow or solid internodes. The fossil record of grasses is poor. The oldest probable grass fossils have been relagated to *Phragmites* (Elias, 1942). Such plants might have had hollow internodes as do the Arundineae of the present day. On the other hand, the families most closely related to the Gramineae, the Cyperaceae and Commelinaceae (Ankermann, 1927) have solid internodes as do most other monocotyledons.

Present evidence, though admittedly scanty, suggests that the earliest grasses had hollow internodes, a condition achieved during the differentiation of the earliest grasses from pre-grass solid-stemmed ancestral forms. Evolution leading to the present-day Festucoideae would then have resulted in no change, unless it would be that the internode walls became even thinner and hollowness more extreme. Evolution among the Panicoideae seems to have been toward solid internodes with the Andropogoneae, Maydeae, Aristideae, and Zoysieae being characterized by all or nearly all species having solid internodes.

Alternatively, it is possible that the earliest grasses had solid internodes and that the primitive solid internode condition has been retained generally by the Panicoideae. Hollowness, on the other hand, must have evolved early among the ancestors of the Festucoideae, Oryzeae and Bambuseae, but among the Panicoideae the condition has developed in some species of some genera of some of the less specialized tribes.

Finally, it seems likely that the general and often-repeated statement that internodes of grasses are usually hollow is misleading or incorrect. It is probable that half or more than half of grass species have solid internodes.

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GRASS MORPHOLOGY AND SYSTEMATICS

II. THE NODAL PULVINUS

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ABSTRACT. Most grasses have a swollen pulvinus at the base of the sheath. Many grasses have also a swollen pulvinus at the base of the internode. Some have both, but few have neither. The subfamily Festucoideae is characterized by no culm pulvinus, but a highly specialized sheath pulvinus. The Panicoideae are characterized by a fairly well-developed culm pulvinus but a sheath pulvinus poorly-developed or lacking. The type of pulvinus is probably correlated with the hollow or solid internode character, and can be used in systematics.

Grass stems, at least the flowering culms, grow erect. The vertical positioning is accomplished just above the nodes by differential growth, probably auxin induced. However, the tissue that grows differentially may be the swollen base of the sheath (the sheath pulvinus), or the swollen base of the internode (the culm pulvinus). When both kinds of pulvini are produced at the same node, the sheath pulvinus may function during early growth, the culm pulvinus later. According to Hackel (1890). all grasses except *Molinia* have sheath pulvini at least until the internode above has completed its growth. Culm pulvini, according to Hackel, develop about 3 mm. above the true node in all Andropogoneae and Paniceae. Many Bambuseae, as well as *Stipa*, *Eragrostis*, *Pappophorum*, *Arundo*, etc. The majority of Agrostideae, Aveneae, Festuceae, and Hordeae have only sheath pulvini.

The data of Hackel cited above indicate a correlation between presence or absence of culm pulvini and the larger taxonomic subdivisions of the grass family as presently understood (Stebbins, 1956; Brown, 1958). The present study was initiated to test this possibility on a large number of available species.

MATERIALS AND METHODS

Both living and preserved nodes were examined. These were taken from mid-portions of the culm and consisted of the node and about 2 cm. of internode and sheath above and about 2 cm. of internode below. Such pieces were fixed in Navashin's fixative and stored in 70% alcohol. These included many curved ones, but straight ones also were examined. The usual method of examination consisted in splitting the

stem longitudinally through the node and examining the sheath and internode bases, under a dissecting microscope if necessary.

The species examined were either native in central Texas, from Rhode Island, or introduced species growing in the grass nursery. The Rhode Island species were collected by Dr. W. H. P. Emery of Southwestern State College of Texas during the summer of 1958. Seeds of many of the introduced species were supplied by the U.S. Regional Plant Introduction Station at Experiment, Georgia.

The 80 genera and 133 species examined are listed in Table 1 of the preceding paper.

RESULTS AND DISCUSSION

Table 1 of this paper summarizes the results from this study, plus data from the literature, arranged systematically by tribes. In some species it was difficult to characterize the internode as having or not having a culm pulvinus. Such species were characterized as having indefinite culm pulvini.

Hackel's statement that nearly all grasses have sheath pulvini is, in general, true. Of the 136 species included in Table 1, at least 117 or 86 per cent have sheath pulvini. Among the Festucoideae sheath pulvini are nearly always present and well-developed (Figure 1). Among the Panicoideae, sheath pulvini are more often present than not, but they are not as well developed and often shrivel when the culm pulvinus develops (Figure 2).

Among the tribes of the artificial group Phragmitiformes some, such as Stipeae and Danthonieae, have sheath pulvini like those of the Festucoideae; whereas the Bambuseae, Arundineae, and Unioleae have culm pulvini as do the Panicoideae.

Culm pulvini, unlike sheath pulvini, are not uniformly present among grass tribes. Among the tribes of the Festucoideae they are almost entirely lacking. Among the Panicoideae they are characteristically present except in the tribe Sporoboleae. Among the more highly specialized panicoid tribes, such as the Andropogoneae and Aristideae, species without culm pulvini are rare. It is possible that the well-developed sheath pulvinus, absence of a culm pulvinus, and the typically thin-walled hollow internodes of the Festucoideae (previous paper) are correlated, as are culm pulvini and solid or nearly solid internodes in the Andropogoneae and Aristideae. But the Sporoboleae, a tribe of the Panicoideae that lacks culm pulvini, have solid or almost solid internodes.

Muhlenbergia rigens and *Pleuraphis mutica* were the only two

TABLE 1

Sheath and culm pulvini in grasses. Number of species with sheath pulvini and numbers of species in each tribe having definite, indefinite, or no culm pulvini.

Tribe	No. Species	Sheath Pulvinus Present	Culm Pulvinus Present	Culm Pulvinus Indefinite	Culm Pulvinus Lacking
		FESTUCOIDEAE			
Festuceae	13	13	0	2	11
Hordeae	6	6	0	0	6
Phalarideae	4	4	0	2	2
Agrostideae	4	4	0	1	3
Aveneae	2	2	0	0	2
Totals	29	29	0	5	24
		PANICOIDEAE			
		EUPANICOIDEAE			
Paniceae	30	22	20	4	6
Andropogoneae	17	14	14	3	0
Maydeae	2	1	2	0	0
Totals	49	37	36	7	6
		CHLORIDOIDEAE			
Chlorideae	18	18	6	5	7
Eragrosteae	9	8	4	2	3
Pappophoreae	2	2	2	0	0
Zoysieae	4	3	1	2	1
Aristideae	2	2	2	0	0
Sporoboleae	9	8	0	0	9
Totals	44	41	15	9	20
		PHRAGMITIFORMES			
Bambuseae	3	0	3	0	0
Arundineae	2	1	2	0	0
Unioleae	1	1	1	0	0
Danthonieae	1	1	1	0	0
Oryzeae	2	2	0	0	2
Ehrharteae	1	1	0	1	0
Stipeae	4	4	0	2	2
Totals	14	10	7	3	4
GRAND TOTALS	136	117	58	24	54
		117 = 86%		82 = 60%	54 = 40%

species characterized as having neither a sheath nor a culm pulvinus although a few others in the Panicoideae lacked sheath pulvini and had only indefinite culm pulvini. *Eragrostis intermedia* and *Panicum pedicellatum* were so characterized. In all four of these species the base of the internode effected curvature but did not form the swelling above the node that was considered to be the culm pulvinus.

With the evidence available it appears that the culm pulvinus is the primitive condition in the grasses. Among the families most closely related to the Gramineae, the Commelinaceae and Cyperaceae (Ankermann, 1927), there are no sheath pulvini, the stems are solid, and curvature of stems occurs at the basal end of the internode. The evolutionary development of highly specialized sheath pulvini apparently accompanied the development of thin-walled hollow internodes and the loss of culm pulvini. If this reasoning reflects actual evolutionary changes within the Gramineae, then the Festucoideae have the most specialized nodal structure within the Gramineae.

On the other hand, the most primitive ancient grasses may have had

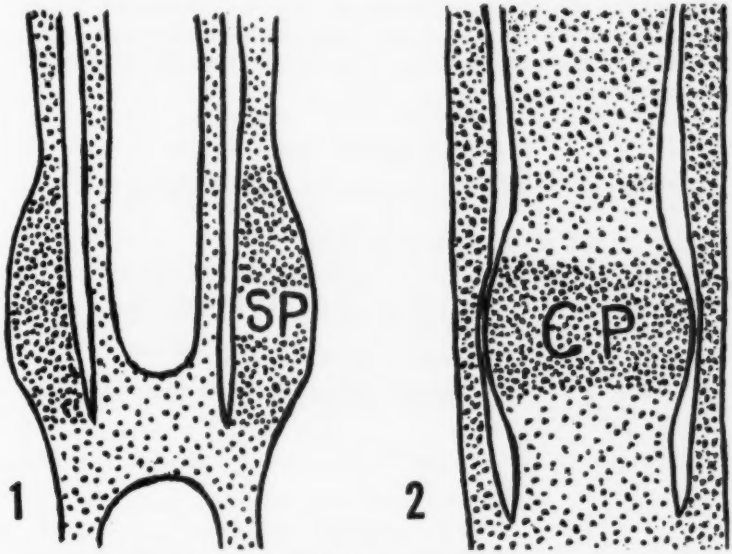

Fig. 1. Grass pulvini. Sheath pulvinus (SP) of *Hordeum vulgare* associated with hollow internodes and no culm pulvinus. Fig. 2. Culm pulvinus (CP) of *Panicum antidotale* associated with solid internodes and no sheath pulvinus.

hollow internodes with culm pulvini. Of the extant grasses, *Phragmites* may be most similar to the ancient grasses of the late Mesozoic and early Cenozoic (cf. Elias, 1942 for discussion of fossil grasses). *Phragmites* has hollow internodes, a culm pulvinus, and no sheath pulvinus (Arber, 1934). During subsequent evolution sheath pulvini have become very specialized in the Festucoideae as that group lost the culm pulvini. Among the Panicoideae there has been an evolutionary tendency toward retention of the culm pulvinus, solidification of internodes, and lack of specialization of the sheath pulvinus.

With almost no fossil record of early primitive grasses it is impossible to decide between the two above alternatives. However, it is probable that the highly specialized sheath pulvinus of the Festucoideae is an advanced and specialized structure. It is likely, too, that the thin-walled internode of that group is a derived condition from solid or thick-walled hollow internodes.

It can be concluded that thin-walled, hollow internodes, highly specialized sheath pulvini, and no culm pulvini are typical of the Festucoideae. Among the Panicoideae thick-walled, hollow or solid internodes, culm pulvini, and either poorly-developed or entirely lacking sheath pulvini are typical. The tribe Sporoboleae is exceptional in the Panicoideae in lacking the culm pulvinus as an identifiable morphological structure.

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ADDITIONAL DRAGONFLIES (ODONATA) FROM ARKANSAS

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ABSTRACT. Only 24 species of odonates are recorded in the literature from Arkansas. Basic collection data are given for 28 additional species.

Adams (1900) published the first and apparently the only list of dragonflies of Arkansas. He records the following 17 species from Marion County: *Erpetogomphus designatus, Dromogomphus spinosus, Gomphus hybridus* (as *fraternus*), *G. lividus* (as *sordidus*), *Aeschna* sp., *Boyeria vinosa, Libellula pulchella, Plathemis lydia* (as *trimaculata*), *Tarnetrum corruptum, Pachydiplax longipennis, Agrion maculatum, Hetaerina americana, Argia apicalis, A moesta* (as *putrida*), *A. sedula, A. tibialis, Enallagma exsulans.*

Since publication of this list very few additional species have been recorded. Calvert (1901) discusses the specimens on which the Adams record of *Gomphus fraternus* was based. Westfall (1956) examined the same specimens and concludes that they are *hybridus*. Muttkowski (1910) names Arkansas in giving the distribution of *Libellula quadrimaculata* and Walker's (1925) map includes the state in the range of *Somatochlora filosa*. Needham and Heywood (1929) add *Argia translata* to the state list. Byers (1939) records *Progomphus obscurus* from Lincoln County and Gloyd (1940) lists *Gomphaeschna furcillata* from the same county. Needham and Westfall (1955) add *Cordulegaster obliquus, Libellula incesta, Pantala flavescens* to the state list. Thus 24 named species have been recorded from Arkansas.

I collected briefly in Arkansas on several occasions and also obtained a few specimens from students who collected there. These localities follow (county in caps, nearest state highway map locality, date):

1. CONWAY, Petit-Jean State Park, 6/11–12/58.
2. LOGAN, Booneville, 6 miles south, 6/13/58.
3. LOGAN, Chimsville, 3 miles south, 6/13/58.
4. LOGAN, Cove Lake Resort, Ozark National Forest, 6/12/58.
5. MONTGOMERY, Caddo Gap, 2.4 miles southeast, 6/10/58.
6. PIKE, Antoine, 8/8/53.

7. PIKE, Daisy State Park, 6/9/58.
8. POLK, Mena, 10 miles north, 6/7/50.
9. POLK, east of Beachtown, Oklahoma, 9/17/56.
10. POLK, Cove, 1 mile south, 4/16/59.
11. POLK, Mena, 3 miles south, 4/16/59.
12. SCOTT, Hon, 1 mile east, 6/13/58.
13. SEBASTIAN, Greenwood, 6/23/51.
14. SEVIER, Locksburg, 4 miles south, 6/12/57.

At these localities 28 species not previously recorded from Arkansas were collected. In the following list numbers in parentheses refer to the above basic data. Most specimens are in the author's collection but a few have been given away in exchanges.

Tachopteryx thoreyi (Hagen) (8), 1 ♂. *Hagenius brevistylus* Selys (6), 2 nymphs. *Gomphus (Arigomphus) lentulus* Needham (12), 3 ♂; (13), 4 ♂, 1 ♀. *Gomphus (Gomphus) graslinellus* Walsh (2), 3 ♂; (13), 1 ♂. *Basiaeschna janata* (Say) (9), 1 nymph. *Anax junius* Drury (1), 1 adult, sight. *Nasiaeschna pentacantha* (Rambur) (1), 1 adult, abdomen missing; (3), 2 ♂. *Didymops transversa* (Say) (6), 1 nymph. *Epicordulia princeps* (Hagen) (4), 1 adult, sight; (7), 1 adult, sight. *Tetragoneuria cynosura* (Say) (6), 1 very immature nymph; (10), 1 ♂. *Perithemis tenera* (Say) (1), 2 ♂, sight; (5), 4 ♂, sight; (12), 4 ♂, sight; (13), 1 ♂. *Celithemis elisa* (Hagen) (1), 1 pair in tandem, sight; (4), 1 adult, sight; (5), 5 ♂. *Celithemis fasciata* Kirby (1), 1 adult, sight; (5), 4 ♂, 1 ♀. *Celithemis verna* Pritchard (5), 1 ♂. *Libellula cyanea* Fabricius (1), 1 ♂, 1 ♀; (5), 1 ♂; (12), 1 ♂; (13), 2 ♂. *Libellula flavida* Rambur (13), 1 ♀. *Libellula luctuosa* Burmeister (2), 1 adult, sight; (3), 1 adult, sight; (5), 2 ♂; (12), 2 adults, sight; (13), 1 ♂. *Libellula vibrans* Fabricius (3), 1 ♂. *Erythrodiplax connata minuscula* (Rambur) (5), 1 ♂. *Sympetrum ambiguum* (Rambur) (1), 1 ♀; (3), 2 ♂. *Erythemis simplicicollis* (Say) (1), 1 adult, sight; (3), 1 adult, sight; (5), 1 ♀; (12), numerous adults, sight; (13), 1 ♂, 1 ♀. *Tramea lacerata* Hagen (1), 1 adult, sight; (4), 5 adults, sight; (5), 6 adults sight; (12), 4 adults, sight.

Argia violacea (Hagen) (1), 4 ♂, 2 ♀; (2), 1 ♂; (5), 1 ♂; (7), 1 ♂; (11), 1 ♂. *Enallagma basidens* Calvert (12), 1 pair in tandem. *Enallagma divagans* Selys (1), 1 ♂; (7), 2 ♂; (14), 1 ♂. *Enallagma signatum* (Hagen) (1), 1 ♂; (4), 1 ♀. *Ischnura posita* (Hagen) (1), 1 ♂, 1 ♀; (2), 2 ♂; (5), 1 ♀; (7), 1 ♀; (14), 1 ♂, 1 ♀. *Anomalagrion hastatum* (Say) (4), 7 ♀; (12), 1 ♂, 1 ♀; (14), 1 ♂, 1 ♀.

Based on U.S. distribution, these 28 species are all eastern and would be expected in Arkansas. These additions bring the total number to a

mere 52 species, reported from but 10 of Arkansas' 75 counties. Because so few counties are represented and because 101 species are recorded from Louisiana (Bick, 1957) and 126 from Oklahoma (Bick and Bick, 1957), it is certain that more than 52 species occur in Arkansas. It is hoped that this list will serve as a stimulus for additional collecting in the state.

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SEASONAL OCCURRENCE AND ABUNDANCE OF BATS (CHIROPTERA) IN NORTHWESTERN TEXAS

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ABSTRACT. Studies of the biology of hibernating and summer colonies of bats as well as of other smaller harborages in northwest Texas from 1956 to 1959 have provided a better understanding of bat distribution on the high plains. Nine species of bats are recorded herein including the second state record for *Lasionycteris noctivagans*, the easternmost record of *Pipistrellus hesperus* in Texas; the westernmost record of *Pipistrellus subflavus;* and the first record of *Tadarida molossa* from northwest Texas. The zoogeographical affinities and seasonal occurrence of all of the bats recorded from northwestern Texas are discussed.

Northwestern Texas and adjacent areas in New Mexico, Colorado, and Oklahoma have been largely neglected in the faunal surveys of the United States. The mammals of these areas have been studied more than other animal groups, but knowledge of mammalian occurrence, abundance, and ecology is far from complete. Two faunal survey reports (Strecker, 1910; Blair, 1954) contain most of the available information about the mammals of northwestern Texas.

The present report is based on 29 bat skins in the Texas Technological College Zoology collections and on 4,167 banding records which cover the period from September, 1956, through April, 1959.

This work was supported by research grant No. 1246 from the National Institutes of Health to Dr. Russell W. Strandtmann. We are grateful to the NIH for financial supports and to Dr. Strandtmann for his cooperation and participation in our studies. We are indebted to Dr. W. Frank Blair for confirming our identifications, and to the U.S. Fish and Wildlife Service for providing bat bands. For field participation, we are indebted to numerous Texas Tech faculty members and students, especially Chester Rowell, R. W. Strandtmann, Ted Tibbetts, Colene Amondson, Jessie Hillman, and Carl Hott. We also wish to express our appreciation to the many people who have permitted us to carry out our investigations on their lands, reported locations of bat colonies, or contributed individual bats. In particular, we are grateful to O. W. English, Weldon Fromm, J. A. Hedgecoke, Floyd Richardson, H. C. Teague, and R. W. Walkup.

METHODS

All of our records are based on bats taken at roosting sites. We have made no attempts to sample flying bats. Blair (1954) collected both roosting and flying bats, but recorded only one species not recorded by us. Several people brought bats to us from daytime roosts in public buildings in Lubbock, but most of our records were obtained in caverns, caves, buildings, crevices, and other sites where bat colonies had been reported or were expected. Whenever possible, bats were caught by hand. In cases when this method was not feasible, we used forceps to extricate the bats from crevices, a bee smoker to drive them from attics, and Japanese mist nets and parachutes spread over points of emergence from buildings. Parachutes for this purpose were tried experimentally in the summer of 1958 with good results. The (lower) open side is placed against the wall of the building like a bowl over the places where the bats emerge. The sides of the "bowl" and the free edges are drawn in and folded under to make a long, triangular chute with its apex at the bottom. The apex is left open and a container is placed under it. An emerging bat is funneled into the container. The parachutes appear to have no deterrent effect on bat emergence, and it is easier to free a trapped bat from the container than from a mist net. The only disadvantage in the use of parachutes is that they capture bats from only one direction whereas a mist net will snare both departing and returning bats.

Our primary interest in banding bats was to facilitate recognition for studies of their population dynamics. The first individuals of each species encountered were placed in the Texas Tech skin collections. For banding purposes, type 1A bands were used. Studies of the population dynamics of several bat colonies will be reported in subsequent papers.

AREA AND LOCALITIES

Northwestern Texas lies in the southern part of the Kansan biotic province of Dice (1943) and Blair (1950). The southern portion of this province has been divided into three biotic districts: the Mixed-Grass Plains, the Mesquite-Plains, and the Short-Grass Plains (Blair and Hubbell, 1938; Blair, 1950, 1954). Most of northwest Texas lies in the latter two districts. The Mesquite Plains lie to the east of the escarpment of the Llano Estacado, and the Short-Grass Plains lie to the west and above the escarpment. The Mixed-Grass Plains enter Texas only in a relatively small area in the east-central panhandle (Blair, 1954, Figure. 1.)

Along the escarpment of the Llano Estacado and along river canyons, there are solution caves, overhangs, crevices in the gypsum formations. These natural habitats harbor many bat colonies, especially in the winter. On the plains themselves, buildings provide the main bat refuges. The major localities at which we have worked are cited below. The italicized words indicate the names by which the localities will be listed in the account of species. Minor localities will be cited in the discussions of the species.

MIXED-GRASS PLAINS BIOTIC DISTRICT:

Shamrock. Two caves on the North Fork of the Red River, 2 miles north of Shamrock, Wheeler County. This is actually a minor locality, but is our only locality in this biotic district.

MESQUITE PLAINS BIOTIC DISTRICT:

Justiceburg. A twisted and recurving canyon 3 to seven miles east of Justiceburg, Garza County. Bats were captured in crevices and overhangs and most abundantly from old nests of the cliff swallows *(Petrochelidon pyrrhonota).*

Blanco Cayon. A nursery colony of Big Brown Bats inhabits a barn which overlooks the White River on the O. W. English Ranch, 5 miles east of Crosbyton, Crosby County.

Panther Cave. A large cave near the Pease River on the Floyd Richardson Ranch, 22 miles southeast of Childress, Cottle County. (The locations of Panther and Walkup caves as given by Blair, 1954, are in error.)

Walkup Cave (also known as Gregory Cave or Lazare Cave). A large cavern near the Pease River on the R. W. Walkup Ranch, 25 miles southeast of Childress, Hardeman County. This cave is about 2 miles east of Panther Cave and there is considerable interchange of bats between the two.

Bat Cave. A small cavern on the Buckle "L" Ranch, 10 miles south of Childress, Cottle County.

Styx Cave. A large cave emptying into the South Wichita River on the Bateman Ranch near the 6666 ranch line fence, 8 miles east of Guthrie, King County. This cave contains the largest *Myotis velifer* population of any of our localities, but little work was done here because it was not discovered until late in the study.

SHORT-GRASS PLAINS BIOTIC DISTRICT:

Lubbock. Scattered records from buildings and trees in Lubbock, Lubbock County.

McAdoo. Two nursery colonies of Big Brown Bats in the Methodist

Church (SW and NE gables) and another in the school gymnasium at McAdoo, Dickens County.

Los Lingos Canyon. A large canyon with many crevices, overhangs and cliff swallow nests, 15 miles southeast of Silverton, Briscoe County.

Palo Duro Canyon. Sinkhole Cavern, Crawlway Cave, and Fissure Cave on the J. A. Hedgecocke Ranch, 29 miles south of Claude, Armstrong County. All three caves are locted about two miles from the rim of Palo Duro Canyon and all are within 200 yards of each other. There is considerable interchange of resident bats between the three caves, so the resident bats have been treated as a single population.

ACCOUNT OF SPECIES

Nine species have been recorded by us, two others by other workers, and one species recorded in an adjacent area in New Mexico may occur in west Texas.

Myotis lucifugus (LeConte). Little Brown Bat. This species has not been recorded from northwestern Texas, but Bailey (1931) recorded it from Union County, New Mexico, which adjoins the northwest corner of the Texas Panhandle.

Myotis velifer incautus (Allen). Cave Bat. Records of this species exist for every month of the year. Cave Bats are the most numerous winter bats in all three biotic districts. Hibernating colonies in caves reach a density exceeded only by the summer colony of *Tadarida brasiliensis mexicana* in Bat Cave. Fluctuations in the sex ratio and density of the hibernating *Myotis* colonies will be reported elsewhere (Tinkle and Milstead, in press).

Cave Bats become relatively rare in northwestern Texas during the summer months, a fact noted by Blair (1954). Of 3,295 total records of this species, only ten are summer records. The scarcity of these bats during the warm months may be more apparent than real, however. Twente (1955) in working with the same species in Kansas and Oklahoma recorded some sites with both summer and winter aggregations, other with only winter aggregations, and still others with only summer aggregations. He found that many bats which wintered in one cave summered in another in the same general area. Cave Bats may seem scarce in northwestern Texas in the summer because their summer residences have not been found. There is no apparent reason why the larger caves known to us are not suitable for Cave Bat harbors in the summer. Panther Cave and Sinkhole Cave each has two main chambers, an upper one near the surface of the ground and a lower one

with a floor below the water table. Styx Cave and the lower chambers of Panther and Sinkhole caves may be too cool for *Myotis* in the summertime, but the upper chambers of the latter two are not. No bats inhabit the upper chamber of Panther Cave in winter or summer, but large quantities of guano on the floor indicate that at one time it has been used by summer colonies of bats, presumably *Myotis velifer* or *Tadarida brasiliensis mexicana.*

There are seven Cave Bat skins in the Texas Tech collections: two from Los Lingos, October 2, 1956; one from Shamrock, October 20, 1957; and four from Panther Cave, one on February 15, 1958, and three on February 8, 1959. Altogether, 3,288 individuals of *Myotis velifer* have been banded: 14 at Shamrock; 1 at Justiceburg; 577 at Panther Cave; 1,129 at Walkup Cave; 85 at Styx Cave; 2 in buildings in Crowell, Foard County (Mesquite Plains); 4 at Los Lingos; 1,468 at Palo Duro; and 8 in a barn on the Howe Wildlife Refuge, 5 miles east of Canadian, Hemphill County (Short-Grass Plains).

Lasionycteris noctivagans (LeConte). Silver-haired Bat. The Texas Tech collections contain one adult specimen taken in a store in downtown Lubbock on November 11, 1958. This is the second record from Texas; Blair (1952) lists the first as Medina County in central Texas.

Pipistrellus hesperus (Allen). Western Pipistrelle. This species is of infrequent occurrence in northwestern Texas, and has been recorded only from the Mesquite Plains. The Texas Tech collections contain four specimens. Three are from Justiceburg: an adult male collected April 7, 1956, and two adult males collected April 7, 1957. The fourth specimen is an adult female collected at Panther Cave on February 8, 1959. These are the first records of the Western Pipistrelle in northwest Texas, and Panther Cave is the easternmost record of the species in Texas.

Pipistrellus subflavus (Cuvier). Eastern Pipistrelle. There is only one record of this species, an adult male collected in Fissure Cave at the Palo Duro locality on February 22, 1958. This first record from northwest Texas is the westernmost record of the species, and indicates an overlap in the ranges of the eastern and western pipistrelles. Fissure Cave is about 100 airline miles west of Panther Cave (see *P. hesperus*, above).

Eptesicus fuscus pallidus Young. Big Brown Bat. Records of this species exist throughout the year. It is abundant in the summer months, when females aggregate in large nursery colonies. One small nursery colony was found in a crevice at the Justiceburg locality, but all others located by us have been in buildings. Many records of solitary individuals and

mixed-sex aggregations are from natural habitats: caves, crevices, overhangs, and cliff swallow nests. Winter records of the Big Brown Bat are scarce. Winter aggregations are rare and are not nearly as large as the summer nursery colonies. These bats appear to hibernate singly. No clusters have been found.

There are eight skins in the Texas Tech collections: three from Justiceburg in September and October, 1956; four from Los Lingos in September and October, 1956; and one from McAdoo in October, 1957. Bands have been placed on a total of 629 individuals: 62 at Justiceburg; 2 from cliff swallow nests 15 miles southeast of Post, Garza County (Mesquite Plains); 56 at Blanco Canyon; 1 in the school at Roaring Springs, Motley County (Mesquite Plains); 1 at Panther Cave; 3 at Walkup Cave; 1 in a building in Lubbock; 6 in the First Baptist Church at Ralls, Dickens County (Short-Grass Plains); 377 in McAdoo; 1 in an abandoned railroad tunnel on the Saul Ranch, 7 miles southwest of Quitaque, Floyd County (Short-Grass Plains); 113 at Los Lingos; and 6 at Palo Duro. Strecker (1910) records a specimen from Goodnight, Armstrong County, and Blair (1954) records nine specimens from nine miles east of Stinnett, Hutchinson County. Both of these last records are in the Short-Grass Plains. Tibbetts (1956) has reported on homing behavior of some Big Brown Bats and Mexican Freetails banded at Justiceburg during this study.

Lasiurus cinereus (Beauvois). Hoary Bat. This species is of infrequent occurrence in northwestern Texas. The Texas Tech collections contain two specimens: an adult male collected at Los Lingos on October 23, 1956, and an adult female taken in Lubbock on March 24, 1959. Another adult female was banded in Lubbock on April 3, 1957. All three of these individuals were taken from roosting places in trees. Eads *et al.* (1956) report a specimen from Lubbock in April, 1956, and another in Seagraves, Gaines County (Short-Grass Plains), in August, 1956.

Lasiurus borealis borealis (Miller). Red Bat. Blair (1954) recorded one specimen of this species from the Short-Grass Plains biotic district, 9 miles east of Stinnett, Hutchinson County.

Corynorhinus rafinesquei pallescens (Miller). Lump-nosed Bat. This species is a year-around resident in northwestern Texas, but has never been recorded in large numbers. There are four specimens in the Texas Tech collections, two females and a male from 15 miles southeast of Post, Garza County (Mesquite Plains), and the fourth specimen, a male, from Panther Cave. Bands have been placed on 61 individuals: 2 in an erosion tunnel between the town of Justiceburg and Post,

Garza County (Mesquite Plains); 14 at Panther Cave; 21 at Walkup Cave; 1 in a mine shaft at Acme, Hardeman County (Mesquite Plains); and 23 at Palo Duro. Lump-nosed bats usually hibernate solitarily, but one cluster of 20 individuals was found in Sinkhole Cave at the Palo Duro locality on December 13, 1958. The bats were not tightly clustered like hibernating *Myotis*, but rather loosely with a small amount of space between them.

Antrozous pallidus (LeConte). Pallid Bat. Taylor and Davis (1947) record this species from the Texas Panhandle.

Tadarida brasiliensis mexicana (Saussure). Mexican Freetail Bat. This species is the most abundant summer resident in northwestern Texas. Individuals have been recorded from late April to early November, but not at other times of the year. One adult female collected at Justiceburg on September 17, 1956, is in the Texas Tech collections. Bands have been placed on 188 individuals: 9 at Los Lingos; 2 in buildings at Lubbock; 1 at McAdoo; 18 at Justiceburg; 1, 15 miles southeast of Post, Garza County (Mesquite Plains); and 157 at Bat Cave. Blair (1954) records a specimen from a tree at Crosbyton, Crosby County (Short-Grass Plains). Panther Cave may have been used by summer colonies of these bats in the past (see *Myotis velifer* above). This first visit to Bat Cave was on October 11, 1958. At that time, the cave contained several thousand Mexican Freetails. A week later, no bats were found in the cave. This record of departure of Mexican Freetails and our records of arrival in April agree with the dates of migratory movements of these bats given by Cagle (1950) for Ney Cave on the Edwards Plateau of central Texas.

Tadarida molossa (Pallas). Big Freetail Bat. One record of this species, an adult female collected in a Lubbock filling station on October 21, 1956, is the first of this species from northwestern Texas.

BIOGEOGRAPHICAL RELATIONSHIPS

All twelve species of bats in northwestern Texas are found or presumed to occur in the Short-Grass Plains biotic district. Five of the twelve have been recorded from the Mesquite Plains biotic district, and three others *(Pipistrellus subflavus, Lasiurus cinereus,* and *Lasiurus borealis)* are presumed to occur there. Seven of the twelve species of bats have been recorded only once or only a few times and may be only migrants or occasionals. Three species *(Myotis velifer, Eptesicus fuscus,* and *Corynorhinus rafinesquei)* are year-around residents and *Tadarida brasiliensis mexicana* is a summer resident. One species *(Myotis lucifugus)* has not been recorded but is expected as a migrant

or occasional. The four resident species have been recorded from both the Short-Grass and Mesquite Plains, and *Myotis velifer* has also been recorded from the Mixed-Grass Plains.

There are no endemic species of bats in the central grasslands of the United States and Mexico, nor is any species particularly characteristic of the area. The chiropteran fauna of the Kansan biotic province in northwestern Texas is composed of four faunal elements. Five species *(Myotis lucifugus, Lasionycteris noctivagans, Eptesicus fuscus, Lasiurus cinereus,* and *Lasiurus borealis)* are transcontinental in distribution. One species *(Pipistrellus subflavus)* is predominantly eastern in distribution, and four species *(Pipistrellus hesperus, Corynorhinus rafinesquei, Antrozous pallidus,* and *Tadarida molossa)* are predominantly western. Two species *(Myotis velifer* and *Tadarida brasiliensis mexicana)* have the major portion of their range in Mexico. Only the transcontinental and Mexican faunal elements are represented by the four species considered as residents.

Blair (1954) has pointed out that the central grasslands are important biogeographically as an east-west distribution barrier to forest-adapted species, and are simultaneously important as a dispersal route for western and southwestern forms adapted to arid or semi-arid conditions. The Short-Grass Plains are particularly suited to invasion from the west and southwest because of their proximity to the mountains of New Mexico and southwestern Texas, because of the altitude of the Llano Estacado, and because of the dispersal route provided by the Canadian River in its west-east bisection of the area. Of the twelve species of bats recorded in northwest Texas, six represent the western and Mexican faunal elements, while only one represents the eastern faunal element. All others are trans-continental. It is noteworthy that the one eastern species is represented by a single specimen which was collected near the Prairie Dog Town Fork of the Red River; one of the major watercourses of the area.

SUMMARY

Eleven species of bats have been recorded from northwestern Texas and one additional species is presumed present. Four species are recorded from this area for the first time. Because of their rarity, seven of the species are presumed to be migrants or occasionals in northwest Texas. Three species are year-around residents and one is a summer resident. Of the 12 species, five are transcontinental in distribution, one is predominantly eastern, four are predominantly western, and two are predominantly Mexican. One of the transcontinental species

(Lasionycteris noctivagans) is recorded from Texas for the second time. The northwest Texas record of the eastern species *(Pipistrellus subflavus)* is the westernmost record of this species to date.

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NOTES ON OKLAHOMA SLUGS, WITH ADDITIONS TO THE PREVIOUSLY KNOWN FAUNA*

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ABSTRACT. Ten species of slugs, representing four families, are known from Oklahoma. Three of these, *Limax marginatus* (Müller), *Pallifera hemphilli marmorea* Pilsbry and *Veronicella krausi* (Férussac) are reported from Oklahoma for the first time. The distribution of each species within Oklahoma and a few ecological observations are given.

Slugs are the least-known members of the Oklahoma gastropod fauna. Published records are scanty and ecological data with direct bearing upon this particular area, as far as I can discern, are nonexistent. The following is a report of the published records and of collections made during the spring and fall of 1958 and during March and April of 1959. The following ten species of slugs in four families are recorded from Oklahoma: Philomycidae—*Philomycus carolinianus flexuolaris* Rafinesque, *Pallifera fosteri* Baker, *Pallifera hemphilli marmorea* Pilsbry and *Eumelus (Pallifera) wetherbyi ragsdalei* Webb; Limacidae—*Limax flavus* Linnaeus, *Limax marginatus* (Müller), *Deroceras laeve* (Müller) and *Deroceras reticulatum* (Müller); Arionidae—*Arion circumscriptus* Johnston; and Veronicellidae—*Veronicella krausi* (Férussac). One specimen of *Veronicella* was deposited with Dr. H. B. Baker at the University of Pennsylvania. All other specimens were retained by the author.

Slug hunting in Oklahoma was unrewarding until three years ago, when the rains brought relief from a long drouth. With the return of propitious moisture slugs became so abundant, that during the spring of 1958 one could scarcely turn over a rock without finding a few of these mollusks. In Stillwater it is not uncommon to find a large *Limax flavus* L. gliding across the floor in one's home.

Philomycus carolinianus flexuolaris Rafinesque

Oklahoma records: "Indian Territory" (Pilsbry and Ferriss,

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1906), Cherokee County (Waller and Dunlap, 1954), McCurtain County (Webb, 1954), Choctaw and Delaware counties (Dundee, 1955).

Collections: Sequoyah and Latimer counties.

The two collections herein reported leave none of the eastern Oklahoma counties lacking in records for this philomycid gastropod. *Philomycus carolinianus* can be confidently expected in all of the counties adjacent to those listed above.

It has been my experience that this mycophagous species is largely nocturnal. In May of 1958 specimens up to 100 mm. in length were found in the Oklahoma Ozarks crawling about on the vertical sides of lichen-covered limestone boulders and tree trunks after sunset. When touched the large slugs exuded copious amounts of a white sticky substance which is assumed to be distasteful to would-be predators. During daylight the animals were found under fallen trees and rocks which overlaid forest litter.

Pallifera fosteri F. C. Baker

Oklahoma records: Red River flood plains, McCurtain County (Wallen and Dunlap, 1954).

Collections: None.

This species probably occupies several of the counties adjacent to McCurtain County, but this will have to be verified by intensive collecting.

Pallifera hemphilli marmorea Pilsbry

Oklahoma records: None.

Collections: Ft. Gibson, Muskogee County.

Pilsbry (1948) listed several Missouri localities for this species but none elsewhere. In addition to two specimens found at the Oklahoma site, Mr. C. J. McCoy collected one specimen two miles north of Cinncinati, Washington County, Arkansas. In both places the small mottled slugs were found under limestone rocks with *P. carolinianus* and *Deroceras laeve.*

Eumelus (Pallifera) wetherbyi ragsdalei Webb

Oklahoma records: Beavers Bend State Park, McCurtain County and Robber's Cave State Park, Latimer County (Webb, 1954).

Collections: None.

Limax flavus Linnaeus

Oklahoma records: Payne County (Wallen and Dunlap, 1954), McCurtain County (Dundee, 1955).

Collections: Ottawa, Delaware, Adair, Cherokee, Tulsa, Pawnee and Noble counties.

This species does not appear to be specific in its habitat requirements. The Ottawa County specimens were found in three different localities, two specimens from the assorted gravel banks of the Neosho River near Miami, one from the Boone chert deposits near Wyandotte, and six large individuals (83 to 94 mm.) from the mud banks of Horse Creek at Afton. At Grove, Delaware County, the slug was found on a wet lawn; in Tulsa and Pawnee counties it was removed from the sand banks of the Arkansas River, and at Red Rock, Noble County the species was found under decaying leaves. All of the specimens agree with the descriptions given by Pilsbry (1948).

Limax marginatus (Müller)

Oklahoma records: None.

Collections: Oklahoma, Choctaw, Tulsa, Garvin, Seminole, Pottawatomie and Payne counties.

Two specimens of this slug were first collected in 1956 from the Oklahoma State University greenhouse and identified by Dr. J. P. E. Morrison of the U.S. National Museum. The remaining records are based upon collections made from greenhouses located in the county seats of the above listed counties. In all of these places *L. marginatus* was found to be of common occurrence on the moist earthen floors, usually under pieces of broken crockery or wooden planking. Three to a dozen or more individuals were collected from each location.

Deroceras reticulatum (Müller)

Oklahoma records: Noble County (Wallen, 1952) and Payne County (Wallen and Dunlap, 1954).

Collections: McCurtain and Muskogee counties.

This species is common in the greenhouse at Oklahoma State University and in similar localities in the two counties listed above. Under greenhouse conditions this small, dark slug apparently reproduces throughout the year because several sizes were found in any given month. *D. reticulatum* is a pest and causes considerable damage to the young of such plants as strawberries.

Deroceras laeve (Müller)

Oklahoma records: Kay (Wallen, 1952) and McCurtain (Wallen and Dunlap, 1954) counties.

Collections: Pontotoc, Creek, Payne, Ottawa, Delaware and Adair counties.

Deroceras laeve was usually found under logs or rocks lying on moist soil. Those from Creek County, however, were taken by Mr. C. J. McCoy, of Oklahoma State University, from Tiger Creek near Oklahoma State Highway 33. The stream flows fairly rapidly over a

sandy bottom and is approximately four to six inches in depth. The three slugs were removed by dredging in the bottom. It has been known for some time (Pearl, 1902; DeWitt, 1955) that *D. laeve* utilizes standing bodies of water in which to over-winter, but this author was not aware of its occurrence in running streams.

In the plains counties, i.e., Creek, Pontotoc and Payne, *D. laeve* was often found in association with *Polygyra texasiana*, a typical grasslands-cross-timbers species. The first specimen from Pontotoc County was presented to me by Dr. C. J. Dennis of East Central State College, Ada, Oklahoma. The slug, accompanied by five living specimens of *Rumina decollata*, was discovered under an iron pipe lying on sandy soil, the latter species representing an addition to the Oklahoma State fauna (Branson, in press).

In the Ozarkian counties, Ottawa, Delaware and Adair, *D. laeve* was often discovered under the same cover as *L. flavus*, *Mesodon inflecta*, and *Polygyra jacksoni*, the latter two being characteristic forms in these areas. Dundee (1955) reports a *Deroceras* from Delaware County that could be *D. laeve*.

Arion circumscriptus Johnston

Oklahoma records: Choctaw County (Dundee and Dundee, 1958).

Collections: Kay County.

The specimens which Dundee and Dundee found near Boswell, with some polygyrids and *Bulimulus dealbatus*, doubtless represent "escapes" from a greenhouse. The specimens herein reported are 6 to 7 mm. in length, and were collected from a greenhouse in Ponca City on January 1, 1959 by Mr. R. G. Price of the Oklahoma State University Department of Entomology.

Veronicella krausi (Férussac)

Oklahoma records: None.

Collections: Oklahoma County.

On the same day that Mr. Price collected the *A. circumscriptus* he made an additional collection from an Oklahoma City greenhouse. Examination of the collection revealed a member of the family Veronicellidae. Members of this family are widespread in Puerto Rico, the West Indies, Mexico and South America, but are apparently represented in the United States by a single species, *Veronicella floridana* (Leidy), (Pilsbry, 1948). The five specimens herein reported, which measure from 13.0 to 24.0 mm., do not agree with the characters listed by Pilsbry for *V. floridana*. In an attempt to identify these specimens it was found, from subsequent questioning of Mr. Price, that the

owner of the greenhouse had just imported some plants from Puerto Rico.

In its external morphology, i.e., position of the anus and color-pattern, the specimens agree much more closely with Baker's (1925) description of *Veronicella krausi* (Férussac), which occurs in Puerto Rico. However, Hoffman (1925), basing his findings upon the nature of the verge believes *V. krausi* to be conspecific with *V. floridana*. Baker (1928), on the other hand, using both male and female genitalia, restates the problem and retains Férussac's epithet. In cognizance of Baker's (1925) warning that the identification of single specimens based upon external morphology is dangerous, the present author tentatively reports these peculiar gastropods as *V. krausi* until the specimens can be compared with museum material.

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PAST AND PRESENT DISTRIBUTION OF SCALED QUAIL (CALLIPEPLA SQUAMATA) IN OKLAHOMA

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ABSTRACT. A review of regional history was made and very little mention of scaled quail was found. A mail and personal interview and direct observation survey of scaled quail distribution in western Oklahoma was made. From the survey, a population of 980 scaled quail (exclusive of Cimarron County) was estimated to be present in 16 western Oklahoma counties during 1954–1957. A total of 47.1% of the scaled quail tallied in this survey was from the sand sagebrush vegetation type. Any releases made for restocking purposes should be restricted to this vegetation type.

A survey of much of the literature concerning early western travels, particularly on the Santa Fe trail, was made. Careful attention was paid to references to the flora and fauna and particularly to mention of scaled quail. Although buffalo, antelope, prairie dogs, wolves, and coyotes were mentioned frequently, only occasionally was there a remark about quail or partridges. Many of the traders, travelers, and soldiers coming from the East, a region where the bobwhite quail were common, were familiar with bobwhite quail. The distinct appearance, call, and running habit of the scaled quail might, therefore, be expected to attract the attention of these persons.

The Cimarron "cutoff" section of the Santa Fe trail traverses southwestern Kansas, Cimarron County, Oklahoma, and northeastern New Mexico. Most of the area along this trail is presently part of the scaled quail range. Two watering places often mentioned in the Santa Fe Trail literature in Cimarron County, Oklahoma, were the Upper Cimarron (Flag) Springs and Cold Springs. Both of these old campsites are surrounded by rocky bluffs overgrown with wild grapes (*Vitis* spp.), skunkbush (*Rhus trilobata*), and wild currants (*Ribes odoratum*). This vegetation and terrain provide excellent scaled quail habitat. Several coveys of scaled quail were observed in the vicinity of each of these springs from 1954–1956. Although these sites and the

* Oklahoma Department of Wildlife Conservation, Oklahoma State University, U.S. Fish and Wildlife Service, and the Wildlife Management Institute cooperating. I am grateful for the advice and counsel given me by Dr. A. M. Stebler, Unit Leader and Dr. F. M. Baumgartner, Dept. of Zoology, Oklahoma State University, Stillwater.

general area about them at present harbor scaled quail, it is not clear why scaled quail were not mentioned in the published journals of the Santa Fe trail travelers who visited these springs during the main period of travel, 1820–1875.

The most detailed account of scaled quail was given by Abert (1847). He observed and collected specimens of scaled quail along the Rio Grande River near Socorro, and at Fray Cristobal, 40 miles to the south. Abert remarked that "These birds congregate in flocks or coveys of from 20 to 30; . . . they seem to love the low sandy bottoms where the wild sage grows as these bottoms are covered with little knolls, which with sage serve to secure them from their enemies."

Captain Randolph B. Marcy (1852) during his Red River expedition referred to quail as he approached the Llano Estacado, the Staked Plains of the Texas Panhandle. Marcy recorded quail as common in the region about 75 miles west of the Antelope Hills, Roger Mills County, Oklahoma, and 10 miles south of the Canadian River. Quail were noted by Marcy (1850) also in the Guadalupe Mountains of southwestern Texas, and in the region about 75 miles south of Santa Fe, New Mexico. In each of these references, Marcy failed to distinguish the species of quail that he mentioned.

McCauley (1877) traveled extensively in the Texas Panhandle within an area presently bordered by Amarillo, Wheeler, Paducah, and Plainview. A few bobwhite quail were observed in canyons tributary to the Red River along Palo Duro, Tierra Blanca, McClellan, and Mulberry Creeks and the North Fork of the Red River. According to McCauley, "bobwhite strictly avoided the staked plains and rolling uplands." He specifically noted that no scaled, Gambel's, or Mearn's quail were seen in the area traversed.

Goss (1891) reported that bobwhite quail were seen occasionally along the Cimarron River south of Fort Dodge from 1862 to 1866. He did not, however, include scaled quail in his list of Kansas birds.

Hanson (1942) commented on a similar lack of specificity of reference to scaled quail in 65 early historical references that he examined. He, however, included some information in his report on the presettlement distribution of scaled quail in Oklahoma as determined from interviews with early settlers and market hunters. He stated, for example, that market hunting of scaled quail was practiced about 1879 near Grandfield in Tillman County, southwestern Oklahoma. According to Hanson, scaled quail sold at Durham, Roger Mills County, for $1.50 per dozen.

Much of the past distribution of scaled quail in Oklahoma, so far as

known, is illustrated in Figure 1. The extent of the eastward distribution of scaled quail in Oklahoma, according to available records, is not entirely clear. The distributional limits of a game bird along the periphery of its geographic range can be expected to fluctuate with periodic environmental and climatic changes. Tate (1925) noted an extension of scaled quail range of 60 miles during an 18-year period from Cimarron County, Oklahoma, toward southwestern Kansas.

It is oftentimes difficult to distinguish between unofficial stocking attempts and natural movements. People often attempt the stocking of small numbers of scaled quail beyond their main range. On the basis of reports and observations (Figure 1), it was apparent that in the Oklahoma Panhandle the number of coveys of scaled quail tapers off to the east of Cimarron County. A total of 1600 observations of scaled quail was made in various parts of Cimarron County during the period, 1954–1957.

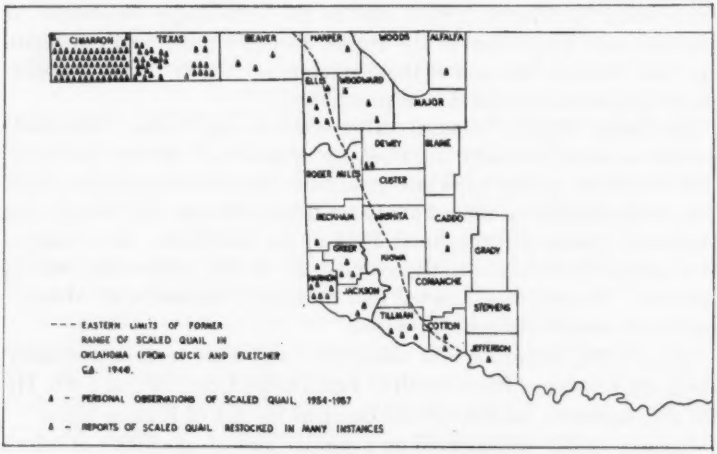

Fig. 1. Past and present distribution of scaled quail in Oklahoma.

A survey was made to ascertain the present distribution of scaled quail in western Oklahoma. One hundred and forty-seven double return addressed postcards were mailed to county agents, vocational agriculture instructors, landowners, sportsmen, and personnel of the Soil Conservation Service and the Oklahoma Department of Wildlife Conservation in western Oklahoma counties. A 74.8 per cent return of these postcards was received. Eighty-seven cooperators reported no

scaled quail, and 23 knew the whereabouts of some scaled quail. The numbers and county distribution of the birds are tallied in Table 1 and plotted in Figure 1. The total of 980 scaled quail reported outside of Cimarron County is, of course, a conservative estimate.

The scaled quail reports have been tallied according to vegetation types recognized by Duck and Fletcher (1943 and *ca.* 1944) in Table 2.

TABLE 1

Population Estimate of Scaled Quail in Western Oklahoma Excluding Cimarron County, 1954–1957

County	Number of Reports	Approximate Number of Scaled Quail
Alfalfa	1	2
Beaver	3	33
Beckham	1	10
Caddo	2	22
Cotton	2	22
Dewey	2	12
Ellis	5	70
Greer	3	102
Harmon	7	87
Harper	1	9
Jackson	2	14
Jefferson	1	12
Roger Mills	1	14
Texas	34	493
Tillman	4	48
Woodward	3	30
Total	72	980

TABLE 2

Occurrence of Scaled Quail by Vegetation Types in Western Oklahoma Exclusive of Cimarron County, 1954–1957

Vegetation Type	Number of Reports	Approximate Number of Scaled Quail
Sand Sagebrush	33	775
Short Grass-High Plains	15	186
Mesquite-Grassland	9	66
Mixed Grass Prairie	7	65
Shinnery Oak	3	46
Postoak-Blackjack	2	22
Tall Grass Prairie	1	2

Since scaled quail were found most commonly outside of Cimarron County, in sand sagebrush vegetation, it is suggested that future releases of scaled quail be made in this vegetation type.

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NOTES

FIRST RECORDS OF TWO SPECIES OF HARVEST MICE IN NICARAGUA.—The University of Kansas Museum of Natural History recently obtained a collection of mammals from Nicaragua, including specimens of the genus *Reithrodontomys* that extend the known ranges of two subspecies.

Reithrodontomys gracilis harrisi Goodwin.—Fifteen specimens from 3 miles southwest of Managua were collected in February, May and June, 1956, by J. R. and A. A. Alcorn. The holotype is the only reported specimen of this harvest mouse, and is from 18 miles northeast of Liberia, Costa Rica. The specimens from Nicaragua were taken 112 miles northward from the type locality. Although the type specimen was not at hand for comparison the specimens from Managua match closely the description by Hooper (Miscl. Publ. Mus. Zool., Univ. Mich., 77: 129–130, 136–137, 1952), which in part states: upper parts pale and bright, having a "peppered" appearance; underparts extensively white; tail distinctly paler ventrally than dorsally; braincase narrower and longer than in *R. g. gracilis* and strongly depressed posteriorly. The specimens (ten adult males and five adult females) have the following average and extreme measurements in millimeters: total length, 167.9(162–173); tail, 99.1(93–108); hind foot, 18.0(17–19); ear, 13.7(13–15); cranial length, 20.8(18.6–22.2); cranial breadth, 10.3(9.9–10.8); length of rostrum, 7.4(6.6–7.9); breadth of rostrum, 4.0(3.7–4.4); alveolar length of upper tooth row, 3.2(2.9–3.5).

Reithrodontomys mexicanus lucifrons Howell.—Two specimens were taken from the following localities: 1 mile northwest Jinotega (adult male); and, 5 miles south and 2 miles east Jinotega (juvenal female). The specimens were collected on April 12, 1956, by J. R. Alcorn. The known range of this subspecies as reported by Hooper (*op. cit.*:150) is from Muya, Honduras, southeast to the Río Coco (near Ocotal), Nicaragua. These new specimens extend the known range 51 miles to the southeast. The following measurements are of the adult male: total length, 182; tail, 106; hind foot, 20; ear, 14; cranial length, 24.1; cranial breadth, 11.4; length of rostrum, 8.5; breadth of rostrum, 3.9; alveolar length of upper tooth row, 3.6.

Grateful acknowledgment is made to Dr. Emmet T. Hooper, University of Michigan, for checking the author's determinations.—*Duwayne C. Englert, Department of Poultry Science, Purdue University, Lafayette, Indiana.*

THE EASTERN HARVEST MOUSE, REITHRODONTOMYS HUMULIS, IN OKLAHOMA.—On April 17 and 18, 1959, the authors, accompanied by Robert R. Patterson, trapped small mammals in Robbers Cave State Park, 5 miles north of Wilburton, Latimer County, Oklahoma. One of the specimens obtained was an Eastern Harvest Mouse, *Reithrodontomys humulis*, a species not until now reported from Oklahoma. The specimen (KU 79852) was trapped at the edge of a grassy clearing in a wooded area along a small creek, the Fourche Maline. Other small mammals collected in this vicinity were *Reithrodontomys fulvescens aurantius*, *Peromyscus leucopus leucopus*, *Sigmodon hispidus texianus*, *Neotoma floridana osagensis*, and *Microtus pinetorum nemoralis*.

The nearest locality at which *R. humulis* is known to occur is approximately 60 miles northeastward at Ft. Smith, Arkansas. One specimen from there was reported

by Sealander (Amer. Midl. Nat., 56: 273, October, 1956) as the only one known from Arkansas, and was not assigned by him to subspecies. Subsequently Hall and Kelson (The Mammals of North America, 2: 584, March 31, 1959) listed this specimen under *R. h. humulis*. The subspecies *R. h. humulis* (known to the east of Oklahoma) and *R. h. merriami* (known to the south of Oklahoma) allegedly differ in color, but our specimen is unfortunately a skeleton. It agrees more closely with *merriami* than with *humulis* if one considers the average cranial and external measurements cited by Hooper (Occas. Papers Mus. Zool., Univ. Michigan, 447: 10, 13, November 5, 1943) and we therefore tentatively assign our specimen to *Reithrodontomys humulis merriami*. The species *R. humulis* (perhaps the subspecies *R. h. merriami*) probably occurs in northeastern Texas, southeastern Oklahoma, and adjacent parts of Arkansas and Louisiana, areas from which it is not now on record.

External and cranial measurements in millimeters of specimen no. 79852 are: total length, 134; length of tail-vertebrae, 61; length of hind foot, 16; length of ear from notch, 12; greatest length of skull, 19.1; condylobasal length, 18.0; zygomatic breadth, 10.0; breadth of braincase, 9.1; length of rostrum, 6.1; breadth of rostrum, 3.9; length of nasals, 6.6; interorbital breadth, 3.2; alveolar length of upper molar series, 3.3; depth of skull, 7.7; length of incisive foramina, 3.9; and length of palate, 3.4.—*J. Knox Jones, Jr. and Sydney Anderson, Museum of Natural History, University of Kansas, Lawrence.*

NOTES ON SOME FLIES REARED FROM BIRD'S NESTS.—Four specimens of an interesting acalyptrate fly were recently received from Dr. Russell Strandtman, who had obtained them by the Berlese technique from the nest of a Great Horned Owl in an oak tree in Bailey County, Texas on May 3, 1959. He informs me that the old nest appeared to be that of a Raven. The flies have now been identified as *Paraleucopis corvina* Malloch 1913 (Proc. U.S. National Museum 46: 149) of the Family Ochthiphilidae (= Chamaemyidae). Malloch's description mentions 14 specimens from Kerr Ranch, New Mexico (J. D. Mitchell, April 23 and May 4, 1910). I have examined the material in the collection of the U.S. National Museum, consisting of 10 specimens including the holotype, of which 9 bear labels reading "on Yucca species" and one is labelled "in raven's nest". Malloch also mentions a single specimen taken by H. Pinkus at Dallas, Texas, May 6, 1910; I have not been able to locate this specimen for comparison.

I know of no published records for this species since Malloch's report; three collections of the species in 49 years might indicate a rare species, but I suspect that inadequate collecting of insects reared from bird's nests is primarily responsible for the apparent rarity.—*Marshall R. Wheeler, Department of Zoology, University of Texas, Austin.*

NEW ARIZONA PLANT RECORDS.—Three species of plants should be added to the list of known Arizona flora. These include one liverwort, *Sphaerocarpus texanus* Aust., and two vascular plants, *Potamogeton crispus* L. and *Bupleurum subovatum* Link.

Sphaerocarpus texanum Aust. *(Sphaerocarpaceae)*. The closest states where collections have been made of this liverwort are California and Texas. The present collection was brought to the author's attention by Raymond Johnson along with several other plants which he had found on the shore of the Salt River below Stewart Mt. Dam, Maricopa Co. The depth of the flow in the river fluctuates according to the

demands for irrigation water so that the level is at its peak in early spring and lower in May. The specimen was growing on the mud flats left exposed in this manner in May, 1958. All specimens were female thalli.

Potamogeton crispus L. *(Potamogetonaceae)* was found growing abundantly in an irrigation tank near Camp Verde, Yavapai Co. This tank is filled by pumping from the Verde River, a distance of approximately one half mile. The collector, George Crowley, recognized the pond-weed as one growing in similar situations in many localities in Utah. Abrams (*in* "An Illustrated Flora of the Pacific Coast States") records it as from California while Muenscher (*in* "Aquatic Plants of the United States") includes Utah, Wyoming and Oklahoma among the western states in addition to its widespread occurence in the eastern half of the continent.

Bupleurum subovatum Link. *(Umbelliferae)* was sent for identification by Mrs. Ella Thea Smith as part of a collection made near the town of Cave Creek, Maricopa Co. She reports that the plant was first brought to her attention by friends fishing in a nearby impoundment. Gleason (*in* "New Britton and Brown Illustrated Flora" vol. 2, page 624) states that *B. subovatum* is native to the Mediterranean region and is also reported as introduced in Pennsylvania. The broadly elliptic to obovate, apiculate bractlets and the strongly tuberculate or rugose fruit readily separates this species from *B. rotundifolium* L. which is recorded from Tucson in Kearney and Peebles "Arizona Flora". *James A. McCleary, Department of Botany, Arizona State University, Tempe.*

A NEW STATION FOR THE SACRAMENTO MOUNTAIN SALAMANDER IN NEW MEXICO.—The Sacramento Mountain salamander, *Aneides hardii* (Taylor), has been obtained only in the vicinity of Cloudcroft, Sacramento Mountains, Otero Co., New Mexico.

On July 2, 1958, while setting traps for small mammals in the Capitan Mountains, 9500 feet, 10 miles east and 5 miles north of Capitan, Lincoln Co., New Mexico, I found a salamander of this species crawling through the damp grass in an open forest of Douglas fir, white fir, limber pine, ponderosa pine, aspen, and Gamble oak. In many places this growth was open enough so that lush grass covered the soil. A light drizzle had fallen intermittently throughout the day.

On July 3, I searched the area carefully and obtained 19 more salamanders. The animals were concentrated at the head of a canyon which led down the south side of the east-west trending range. Here the soil was rocky. Some rocks were buried in the soil to a depth of a foot or more and covered many cavities and underground passages. The soil was moist throughout the upper inch but was dry below that depth. Some of the salamanders were found on moist soil beneath surface rocks. Others were found beneath sticks lying on the surface of the ground. Some small individuals were found by raking through the upper inch of damp leaf litter. Animals were found singly or in small groups. Under one rock, five individuals were discovered. The vegetation in this area consisted largely of thickets of cliffbush *(Jamesia americana)* 8 to 12 feet in height.

The Capitan Mountains are separated from the White and Sacracramento ranges by a distinct gap through which runs U.S. Highway 380. In the gap, grassland and pinyon-juniper woodland are found, habitats presumably not suited to plethodontid salamanders.

The 20 specimens range in total length from 25.5 to 100.7 millimeters. In number of costal grooves, number of costal folds between digits of adpressed limbs, number of vomerine teeth, character of mandibular teeth, and characters of the toes, these

animals differ in no way from published descriptions of *A. hardii* (Stebbins, R.C., Amphibians of Western North America, U. California Press, 1951: 135–136, and Lowe, C. H., Jr., Copeia, 1950: 92–99). The living specimens had a dark brown dorsal ground color variously mottled with golden or greenishgold blotches. In a few individuals, these blotches fused to form a poorly defined dorsal stripe. Ventrally the animals were light-colored except for a midventral dark streak through which the viscera were faintly visible. The light ventral areas were spotted with melanophores. The specimens are preserved in the University of New Mexico Collection of Vertebrates.—*James S. Findley, Department of Biology, University of New Mexico, Albuquerque.*

INFORMATION FOR CONTRIBUTORS

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CONTENTS

Botany

Grass Morphology and Systematics. I. The Internode. *Walter V. Brown, William F. Harris and Joseph D. Graham* 115

Grass Morphology and Systematics. II. The Nodal Pulvinus. *Walter V. Brown, Gene A. Pratt, and Harold M. Mobley* 126

Zoology

Additional Dragonflies (Odonata) from Arkansas. *George H. Bick* 131

Seasonal Occurrence and Abundance of Bats (Chiroptera) in Northwestern Texas. *William W. Milstead and Donald W. Tinkle* 134

Notes on Oklahoma Slugs, with Additions to the Previously Known Fauna. *Branley A. Branson* 143

Past and Present Distribution of Scaled Quail *(Callipepla squamata)* in Oklahoma. *Sanford D. Schemnitz* . . . 148

Notes

First Records of Two Species of Harvest Mice in Nicaragua. *DuWayne C. Englert* 153

The Eastern Harvest Mouse, *Reithrodontomys humulis*, in Oklahoma. *J. Knox Jones, Jr. and Sydney Anderson* 153

Notes on Some Flies Reared from Bird's Nests. *Marshall R. Wheeler* 154

New Arizona Plant Records. *James A. McCleary* 154

A New Station for the Sacramento Mountain Salamander in New Mexico. *James S. Findley* 155